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Use of indigenous electronic jacquard in handloom for weaving fashionable silk sarees

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***Abstract* - Use of indigenous electronic jacquard in place of mechanical jacquard for weaving traditional and also contemporary fashionable handloom silk sarees is a revolution seen now-a-days in many silk saree weaving clusters of India. This paper aims to make the fashion designers textile technologists to understand the technicality behind the fashionable handloom silk saree which is loom made garment woven using electronic jacquard. The study covers complete phases of conversion by which the modern electronic jacquard which was used with only power looms and shuttle less looms has been made to adopt in handloom. Different models of electronic jacquard exclusively manufactured for the use of handloom industry are recorded. Assembling of lifting modules with electronic components which is the heart of electronic jacquard machine is studied. Use of high capacity jacquard for weaving sarees of different layouts with border, body and pallau to make the saree more fashionable is gathered. Harness building methods adopted, shedding performed and the designing procedure using computer are recorded. Simple operating procedures provided with these machines which are easily followed by the handloom weaver are noted. Attempts made by the authors to make jacquard as IoT to enable simple operation and monitoring is also discussed. The advantages of using electronic jacquard in handloom over mechanical jacquard and its cost effectiveness are compared. From the study it is observed that the indigenous electronic jacquard is going to be the great boon for all the handloom silk saree weaving clusters of India.**

Key words: control box, electronic jacquard, harness building, handloom cluster, layout, module, servo motor, silk saree

I. INTRODUCTION

A sari, saree or shari is a women's garment from the Indian subcontinent that consists of a drape varying from 4.5 to 8 meters (5 to 9 yards) in length and 60 to 120 centimetres (2 to 4 feet) in breadth that is typically wrapped around the waist, with one end draped over the shoulder, baring the midriff [1]. There are various styles of sari manufacture and draping, the most common being the Nivi style, which originated in the Deccan region. The sari is worn with a fitted bodice commonly called a choli (ravike in southern India, and cholo in Nepal) and a petticoat called parkar or ul-pavadai. In the modern Indian subcontinent, the sari is considered a cultural icon.

It is not a wonder that India is the birthplace of some of the most beautiful silk sarees [2]. The treasures of the silk sarees are sought after by every Indian woman across the world for its sheer elegance and unparalleled beauty. As symbol of auspiciousness and harbinger of festivities, the best of Indian silk sarees are preserved for the most important occasions. Fashion designer Aaditya Sharma declared, "I can drape a sari in 54 different styles". Hand-woven, hand-decorated saris are naturally much more expensive than the machine imitations. The overall market for hand-woven saris are still popular for weddings and other grand social occasions. International celebrities have worn traditional sari attire designed by Indian fashion designers.

Saris are woven with one plain end, the end that is concealed inside the wrap called ‘body’ of the saree. Two long decorative ‘borders’ running the length of the sari. One to three-foot section at the other end which continues and elaborates the length-wise decoration is called ‘pallu’. It is the part thrown over the shoulder in the nivi style of draping. Solid colour border, body and pallau have become one of the identifying features of most of the traditional silk sarees of South India. Very rich looking solid colour pallau, body and border sarees, ornamented with the designs of gold zari are always in good demand in the local market for ceremonial wear [3].

More expensive saris have elaborate geometric, floral, or figurative ornaments or brocades created on the loom, as part of the fabric. Sometimes threads of different colours are woven into the base fabric in patterns; an ornamented border, an elaborate pallu, and often, small repeated accents in the cloth itself. These accents are called buttis or bhuttis. For fancy saris, these patterns could be woven with gold or silver thread, which is called zari work. For producing ornamented decorative designs with zari in border, body and pallu, it is essential to use special shedding device along with healds shedding in handloom to operate the vertical warp series of cloth in desired figurative order and introduce horizontal weft pick in the cloth.

The Jacquard machine is a device fitted to a handloom that simplifies the process of manufacturing ornamented decorative design patterns as brocade. It was invented by Joseph Marie Jacquard in 1804 [4]. The machine is controlled by a ‘chain of cards’; a number of punched cards laced together into a continuous sequence which are punched as per the figured design created on graph paper. Multiple rows of holes were punched on each card, with one complete card corresponding to one horizontal row of the design in the graph and one horizontal weft pick in the cloth.

Bonas Machine Company Ltd. launched the first successful electronic Jacquard at ITMA, Milan in 1983 [4]. Although the machines were initially small, modern technology has allowed Jacquard machine capacity to increase significantly, and single end warp control can extend to more than 10,000 warp ends. This avoids the need for repeats and symmetrical designs and allows almost

infinite versatility. The computer-controlled machines significantly reduce the down time associated with changing punched paper designs, thus allowing smaller batch sizes.

Kanjeevaram (Tamil Nadu), Banaras (Uttar Pradesh), Ashavali Brocade (Gujarat), Paithani (Maharashtra), are the well-known traditional silk sarees of India. Jamdhani cotton sarees (West Bengal), Arni (Tamil Nadu) Dharmavaram and Gadwal (Andhra Pradesh), YN Hosakote and Molakalmuru (Karnataka) are also famous for traditional and contemporary silk sarees. During the past two decades, all the said handloom clusters have been adopting modernized methods, machines and mechanism for weaving fashionable silk sarees by dispensing the old techniques used in preparatory, weaving and designing processes [5]. Use of indigenous electronic jacquard in place of mechanical jacquard for weaving traditional and also contemporary fashionable handloom silk sarees is a revolution seen now-a-days in all the above silk saree weaving clusters of India. The value added niche products, produced easily by using handloom electronic jacquard could be sold at high cost, which in turn fetches considerable earnings to the skilled weavers who operate the modernized handloom.

Looking to the demand, the mechanical jacquard manufacturers in India traced the concept of electronic jacquard machine and have started manufacturing indigenous electronic jacquards by producing all the accessories required for assembling [6]. They have also modified the drive of electronic jacquard from continuous to intermittent using servo motor which paved way to use the electronic jacquard for handloom industry. Today silk saree producing centers in India have gradually started using electronic jacquard of capacity ranging from 480 to 5376 ends control. This study highlights how the electronic jacquard in handloom industry has become more useful in place of mechanical jacquard and become more weaver friendly for producing elegant and elaborately figured fashionable handloom silk sarees. The study also highlights the points to be noted by the fashion and textile technocrats about saree layout designing and its graph making. In the study, for explaining the concept, a typical example of electronic jacquard, layout and its relevant harness building, graph making, graph conversion and weaving used in Onnupuram village of Arni silk cluster have been taken for illustration [7].

II. HANDLOOM ELECTRONIC JACQUARD

The indigenous Handloom Electronic Jacquard - HEJ (A in Fig. 1) is built using an array of electro-magnets / solenoids. These magnets are available in the market as magnet modules with 8 magnets enclosed in one module, with necessary mechanisms and thus each module providing 8 Hooks for warp yarn control (B in Fig. 1). These magnet modules are arranged in rows and columns, connected with electronic control boards and enclosed in a specially designed mechanical enclosure. The hooks lifting mechanical mechanism works with double lift principle operated by servo motor (C in Fig. 1). The magnets in the modules are actuated as per the marks and blanks of graph design prepared using textile graph designing software through the Electronic Jacquard Control System (EJCS) assembled in the electronic control box (D in Fig. 1). The weaver can operate the required design by changing the display provided in the control box using buttons. The EJCS along with the arrangement of modules and the mechanical double lifting system put together is referred as Electronic Jacquard.

In India the following are the few manufacturers of handloom electronic jacquard. Sre Corporation Coimbatore, A Cube (Equip) Engineers Coimbatore, Shreetex Engineers Thane, Divine Tex Bengaluru, Udayaravi Enterprises Bengaluru, Shree GPS Bengaluru, Modha Tech Engineering Private Limited, Dharmavaram, Tana Bana Automation Pvt. Ltd. Sholapur, Dashmesh Jacquard Panipat, Amar Jacquard Ludhiyana.

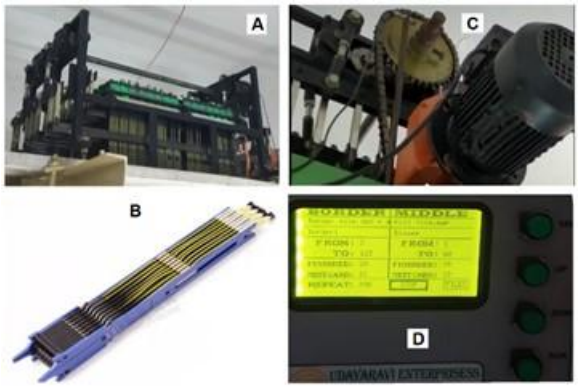

Fig. 1 – (A) Handloom electronic jacquard, (B) Electro magnet solenoid, (C) Servo motor and (D) Control box.

Out of these manufacturers, Modha Tech Engineering Private Limited converted the mechanical jacquard into electronic jacquard by introducing electronic system for the selection of needles from needle board, keeping the other components of mechanical jacquard as it is. Similarly, Tana Bana Automation Pvt. Ltd., converted the mechanical jacquard into electronic jacquard by introducing electronic system for the selection of needles from cylinder side, keeping the other components of mechanical jacquard as it is. Other manufacturers of HEJ are using electro-magnets / solenoids. The hooks capacity of HEJ ranging from 960 to 5376 ends are used in silk saree industry and the common arrangement of 8 hooks modules of different capacities is given Table - I.

TABLE I. - MODULES ARRANGEMENT IN DIFFERENT CAPACITIES OF HEJ.

Hooks	480	960	960	1344	2048	2688	3072	4608	5376
Modules	60	120	120	168	256	336	384	576	672
Columns	10	15	10	14	16	21	24	24	28
Rows	6	8	12	12	16	16	16	24	24

The minimum capacity of HEJ used in silk saree industry is 960 hooks. Fig. 2 shows the arrangement of 120 modules of 960 hooks jacquard in 10 columns and 12 rows standing at weaver's seat. Numbering of hooks starts from front right of the weaver (bottom right in figure) and completes at back left (top left in figure) as given in Fig. 2.

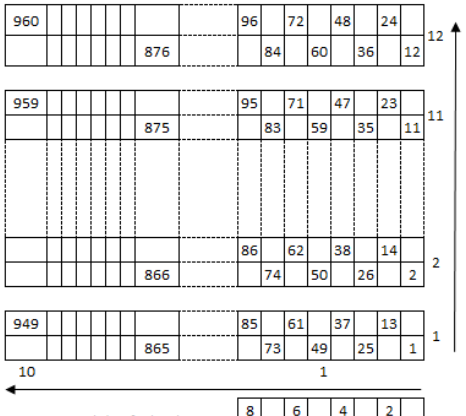

Fig. 2 – Hooks numbering in 960 hooks capacity of HEJ.

III. Colour Layout of Fashionable Silk Saree

Figure 3 shows the solid colour and design layout of fashionable silk saree that could be produced using electronic jacquard. Left side of figure shows the solid colour layout and the right side shows complete design layout embedded with colour layout. Weaving pallau, border and body in solid colour is one of the features of traditional sarees of India which is shown schematically in the left side of figure 3. Solid colour in any part of the saree is obtained by using similar colour in warp and weft.

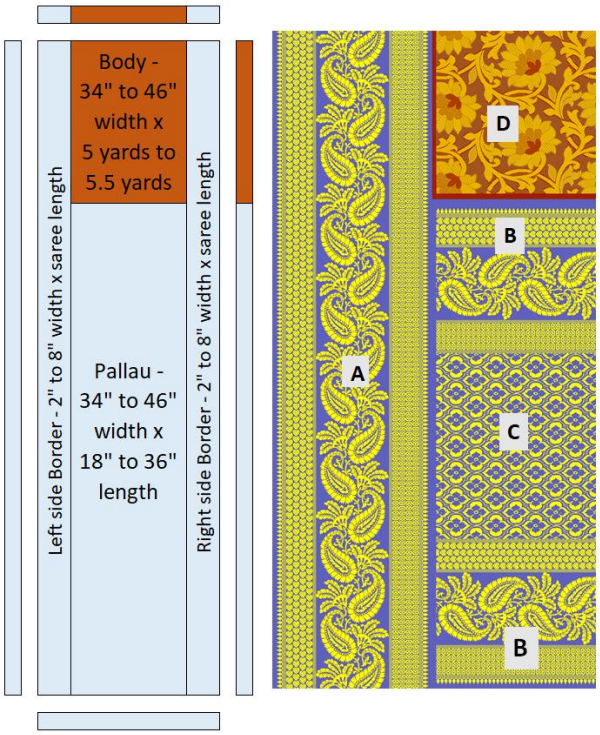

Fig. 3 – Solid colour and design layout of fashionable silk saree.

Out of 5.5 meters length of saree, the first ½ to ¾ meter of 'pallau' is in solid colour for its full width – say blue. The border colour is also same as the colour of pallau, that is blue. The centre body part, leaving the pallu and border is in another solid colour contrast to that of blue – say orange. The purpose of having solid colour for the pallau, border and body is to have it as back ground over which the ornamentations of designs could be shown prominently in extra warp and extra weft principles

IV. Design Layout of Fashionable Silk Saree

Different design layout of silk saree is brought by the combination of extra warp and extra weft weaving principle. The borders of silk saree on both the sides are ornamented mostly with gold zari in extra warp woven using silk ground warp and zari extra warp combined with silk weft. Ground warp is controlled by healds and extra warp ends by jacquard. The figured motif used for extra warp ornamentation is of vertical running nature (A in Fig. 3). The vertical border motif has main border in the centre and supporting borders at the left and right side of main border. All the elements in the repeat of vertical border design get completed both at left and right side and have proper joining at the top and bottom side.

In the centre portion of saree, the pallau is ornamented with extra weft, woven using silk ground weft and zari extra weft combined with silk warp controlled by jacquard. The beginning and end of pallau is normally woven with horizontally running gold zari extra weft figured designs (B in Fig. 3). The horizontal border motif has main border in the centre and supporting borders at the top and bottom of main border. All the elements in the repeat of horizontal border design get completed both at the top and bottom side and have proper joining at the left and right side. The horizontal border design is mostly same as vertical border design, turned to $90^{0.}$ The middle of pallu portion is woven with all over running figured design using gold zari in extra weft principle (C in Fig. 3).

To make the saree very exclusive and elegant, the complete body portion is also woven with all over running figured design using gold zari in extra weft principle (D in Fig. 3). All the elements in the repeat of allover design have proper joining at left and right side and also have proper joining at the top and bottom side. The body portion of saree, sometimes is woven as simple figured cloth using silk warp and silk weft without any extra weft. In this case the colour of weft used is different to that of warp colour and the design is made to have more plain ground with less amount of figure formed by floating silk warp or weft.

In most of the silk saree layouts, along with the above said vertical, horizontal and allover figured ornamentation, buttis woven with gold zari in extra weft principle are also combined. Buttis are placed in border, pallu and body portions of the saree as per the required ornamentation. According to the place where the butti is woven, it is called as Border butti, Pallu butti, Body butti and Corner butti. The butti is called as 'Corner butti' when it is placed in the junction place of border, pallu and body. As seen above, when more attractiveness and ornamentation is required, all the figured design used in border, pallu and border must be more elaborative and gigantic in size. The introduction of electronic jacquard in handloom with huge capacity of hooks has made it possible to achieve this goal easily.

V. Harness Building

Normally total reed width of silk saree is 50" and ends per inch in the reed is 96, making the total number of ends of saree equal to 4800. Fig. 4 shows a typical border and body harness building with 960 hooks HEJ in Norwich system to weave the layout shown in Fig.3. The left side photo shows the handloom fit with electronic jacquard of 960 hooks capacity and the right side photo shows the handloom artisan operating the jacquard by a pedal using his foot. The total capacity of hooks are divided into as many parts as required

to control the ground ends, extra warp ends and body ends. Out of the 4800 ends, say 480 ends on each side is taken as ground ends for extra warp border and the remaining 3840 ends are taken as body ends. Out of 960 hooks, 480 hooks are allotted to control 3840 body ends in multiple repeat in straight order. With the remaining 480 hooks, 456 hooks are allotted for extra warp border in straight order. The remaining 24 hooks are made available for controlling 2 healds which operate ground ends in plain order.

As seen in Fig. 4, right side first 1 to 12 hooks (12) are used to connect right side two healds controlling the ground ends of right side border. Odd hooks of these 12 hooks are connected to first heald and even hooks to second heald. The next 13 to 492 hooks (480) are used to control 3840 body ends in 8 repeats (480 x 8). From 493 to 948 hooks (456) are for controlling extra warp border ends on both sides (right side one repeat and left side one repeat). The left side last 949 to 960 hooks (12) are to connect left side two healds controlling the ground ends of left side border. Odd hooks of these 12 hooks are connected to first heald and even hooks to second heald. Norwich system of harness building is followed for connecting the harness in the comber board in straight order completely in all the places as shown in Fig. 4.

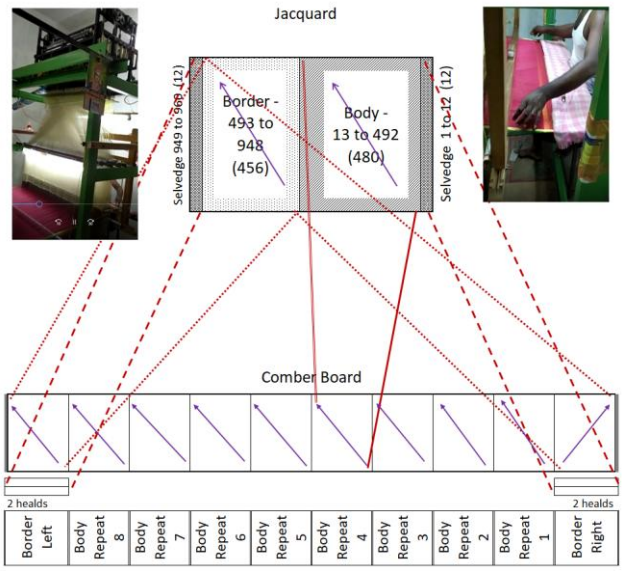

Fig. 4 - Border and body harness building with 960 hooks HEJ in Norwich system.

For drawing the harnesses through the comber board, and the ends through harnesses, numbering of the harness and end must be started from front right to back left, standing at weaver's seat similar to the counting followed for hooks. Sometimes, for the right side border, the counting is reversed from front left to back right to have the right side and left side borders in mirror effect as shown in Fig. 4. Since HEJ produces open shed starting from top of the shed, all the harnesses are initially levelled to keep the ends at the top line of shed which is marked as per the required height of shed from the bottom of reed.

VI. Computer Aided Graph Designing

As per the selected motifs, the graph designs for border, pallu and body are developed in required number of ends (hooks capacity) and picks using any computer aided graph designing software. Finally graph file is prepared in black and white format. The points to be considered while making graph are as follows:

HFJ produces open shed starting from top of the shed. That means, during initial setting, all the ends are at the top of reed. This is opposite to the mechanical jacquard wherein all the ends align at the bottom initially. Hence, the marks and blanks of graph designing for HEJ mean opposite. Black mark in the computer graph design lower the end. White blank in the graph keeps the end at the top.

Face side of the saree for wearing will be on the back side while weaving on loom. Hence, in the silk saree handloom weaving, the required actual zari / silk design effect is produced at the bottom while weaving. In most of the HEJ, the ends of graph file is electronically counted from right to left and the picks are from top to bottom. In the loom, for the weaver, the ends are counted from right to left (become left to right while reversing for wearing) and the picks are woven from bottom to top.

Hence, when making the graph design for extra warp border design, the zari design parts are to be in black mark to lower the zari extra warp ends (A in Fig. 5). This will produce the extra warp zari to float back and make actual zari design effect at the back side while weaving (C in Fig. 5) and then seen on the face side while reversing for wearing (D in Fig. 5). The right - left and top - bottom reversing can also be observed between A, C and D.

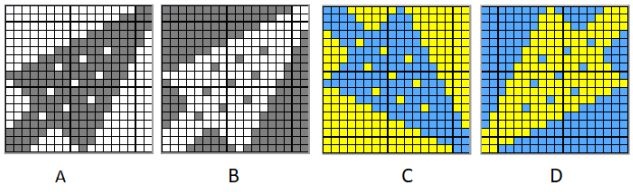

Fig. 5 – Graph making for extra warp border and extra weft pallu and body.

While making the graph design for extra weft pallu and body designs, the zari design parts are to be in white (Blank) to keep the body silk ends at the top (B in Fig. 5). This will produce the extra weft zari to float back and make actual zari design effect at the back side while weaving (C in Fig. 5) and then seen on the face side while reversing for wearing (D in Fig. 5). The right - left and top - bottom reversing can also be observed between B, C and D. Corresponding to the harness building described above, for a typical saree, the border design is prepared in 456 ends x 120 picks size. Different pallu and body designs are prepared in 480 ends x picks of different sizes and combined as one file by keeping all the design files one above the other in the required sequential order of weaving. The total picks of different pallu and body combined design are 2314 for example. (Blouse – 60; First border pallau – 912; All over pallu – 60; Second border pallau – 912; Cross border -10; Body – 240; Plain 120).

VII. Hej Design Conversion Software

All the manufacturers of HEJ provide separate conversion software to convert the designs prepared from the designing software for loading it to HEJ control box. The designs prepared in the designing software are modified by adding additional marks wherever required to control the

operation of other mechanisms like shuttle change, healds change, design change etc.

For example, along with 960 hooks of main figuring capacity, 8 extra vertical lines are added making total file size as 968 hooks. These extra lines are provided to indicate the shuttle selection while weaving extra weft designs with multi shuttles in pallu and body. Similarly two extra picks are added at the top of border design for indicating the selection of shuttles / healds corresponding to the indication given in the pallu body combined design. That is, the border design prepared in 456 x 120 is converted to 456 x 122 by adding 2 picks on the top and marking the top pick in black.

Then both border design and pallu body combined design are placed in the graph of 968 ends size as given in the Table - II, including the marking for control of healds and shuttle. The design file made in 968 ends as above are now ready for taking to HEJ conversion software.

TABLE II. - PLACEMENT OF BORDER AND BODY GRAPH IN TOTAL CAPACITY OF HEJ

Description	Border Design	Body Design - two shuttles	Body Design - single shuttle
1 to 12 -12 hooks - right side healds control	Plain	Blank	Blank
13 to 492 - 480 hooks - body ends control	Blank	Body Design	Body Design
493 to 948 - 456 hooks - border ends control	Border Design	Blank	Blank
949 to 960 - 12 hooks - left side healds control	Plain	Blank	Blank
961 to 968 - 8 hooks - shuttle control	Blank	Black dot in extra weft picks to lower healds	Blank

Fig. 6 shows the window of a typical conversion software with the loading of all the required information.

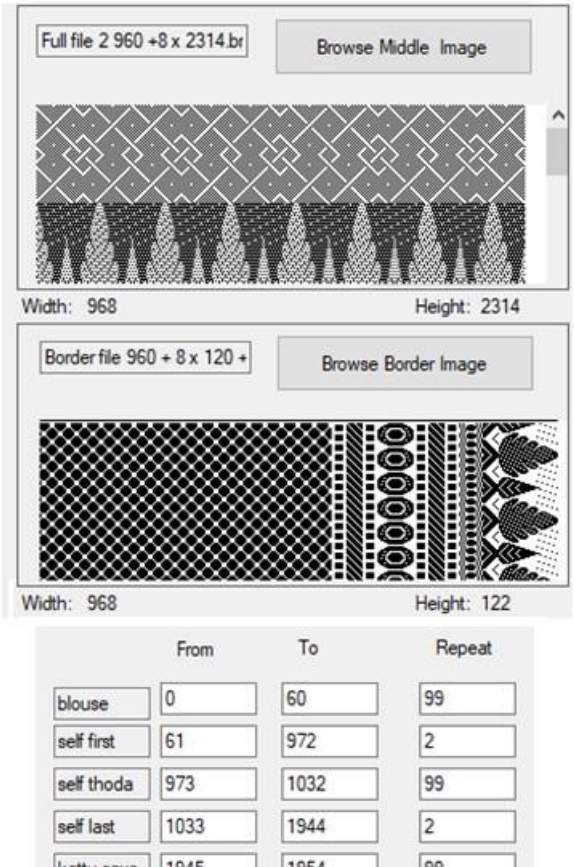

Fig. 6- File loading and file information inputting in the conversion software window.

The HEJ software normally contains window to load the extra warp border design and the pallau and body combined design separately. This is because, for the given length of a saree, the border runs continuously without any change and only the designs of pallu body combined design keep on changing. Hence, provision is also given to load the details of pallu body combined design in required order of sequence indicating the picks numbering and number of repetition of each design. Top of the window shows the loading of border image, and the centre shows the loading of pallu body combined design. At the bottom, the name and pick numbering of each design file of pallu body combined design along with the number of repeats required to weave is indicated in proper weaving sequence. After completion of loading of these files and indicating of pick numbering in the window of conversion software, the file is exported and saved in the memory card. The memory card with this exported file is used in the control box of HEJ kept in the loom near to the weaver's seat.

VIII. WEAVING IN HEJ

The weaver has to switch on the control box (D in Fig. 1) after inserting the memory card having the converted design file. In the control box along with the digital display at one side, is provided with buttons labeled as tab, up, down and run for the operation of menu and files. The tab button is used to select the required Menu. Run button is used to enter into the selected Menu to see the files in it. Up and down buttons are used to change the files, numbering in the selected menu. When switch on the box, the digital display, displays the names of different converted design files in the memory card. The required file is located by up and down buttons and entered into the file by run button. The border file information is loaded in the left side and the information of first design file (Blouse) of pallu body combined file is loaded in the right side. The menu information displayed are file name, total number of cards (from - to), card number finished (woven), next card number, repeat number, stop / run and files.

When the weaver is ready to start weaving, he has to keep the first card of both the files in running position (next card number) and set the stop / run menu into stop position. Now, as per the marks in the first pick of the files, the

corresponding hooks will rest upon the odd knifes at the top. At this position, when the weaver press the pedal (photo shown in Fig. 4), the servo motor pulley rotate one time and bring down the odd knives with the selected hooks which readily rest upon the knives forming the shed. Simultaneously, the even knifes at the bottom lifted with the hooks of last pick. First pick is inserted in the shed.

In the display, the finished card number become 1 and next card number become 2. Now, as per the marks in the second pick of the files, the corresponding hooks will rest upon the even knifes. At this position when the weaver press the pedal again, the servo motor pulley rotate one time and bring down the even knives with the selected hooks readily rest upon the knives forming the next shed. Simultaneously, the odd knifes at the bottom lifted with the hooks of first pick. Now second pick is inserted in the shed. Likewise, the weaver has to simply do pedaling, pick the shuttle and observe the display then and there to confirm the change of card numbering. If anything goes wrong, the weaver has to keep the stop / run menu into run position. He can do forward and backward of card numbering by taking the tab selection to card numbering and pressing the up and down buttons. After completing the weaving of running file, the next file is brought into action by changing the tab to running file and pressing the up button. The weaver can get familiarize to the operation of buttons by getting training for couple of days. The file names are to be given as per the familiar regional terminologies pronounced by the weavers, so that he can read the display easily. Recently, attempts have been made to connect the control box with internet, so that the operations carried in the control box by the weaver could be easily monitored and accessed by the designer and manufacturer from different places. All the three persons can easily discuss and coordinate with each other regarding the progress of design woven in loom sitting at their places.

IX. Cost Effectiveness of Hej

Taking an example, the cost effectiveness of HEJ is calculated as given below.

On an average 2500 cards are used in 960 hooks mechanical jacquard to produce a saree with new design layout which cost Rs. 5,000 for designing and Rs. 10,000 for punched cards.

The set of designs have to be changed for 4 sarees. In one month, 4 sarees are woven using this new set of cards. That means every month Rs. 15,000 has to be invested for the new set of cards when mechanical jacquard is used.

The HEJ of 960 capacity on an average cost Rs. 2,00,000 (Rs. 200 per hook). In weaving with HEJ, for every 4 sarees, new design set is changed which requires only Rs. 5,000 as designing cost and saves Rs.10,000 invested against the punched cards for every month.

At the end of 20th month, Rs. 2,00,000 could have been saved which is equal to the cost of HEJ. That means on an average, within two years, the cost invested on HEJ could be realized and there after saves Rs. 10,000 every month.

X. Advantages of Hej

Following are the advantages of HEJ compared to mechanical jacquard:

The capacity of HEJ ranging from 960 to 5376 is very useful to produce elaborate designs. Single repeating photo realistic design in full width of saree can be easily produced. It is possible to produce high end value added ceremonial silk sarees with advanced weaves like double / treble cloth, backed cloth and tapestry using multi colour warp and weft as given in Fig. 7.

Fig. 7- Elaborate and Elegant saree designs produced using HEJ

Electronic Jacquards also referred as green machines, as it avoids punched cards, hence saving lots of trees and reducing pollution and reduces related cost. Pattern change on HEJ is performed through the electronically operating software which saves considerable time and eliminates design defects.

Loom operation becomes faster, since electronic selection mechanisms and double lift operation by two sets of knives. Stress and strain put upon the silk warp is less because of open shed operation. Hence it is possible to weave silk warp having lesser tenacity values.

Strain on the weaver is less due to simple pressing of pedal irrespective of capacity. Stress of the weaver is also less as he is free from mounting of cards and monitoring proper working of cards in the cylinder.

XI. Conclusion

The study highlighted overall setup and general procedure followed in using HEJ for producing silk sarees with the desired deign layout to make aware how important for the fashion and textile technologists to learn about the HEJ. Looking into the cost effectiveness and manifold advantages of HEJ, all the handloom silk saree manufacturers in Arni, Dharmavaram, Kanjeevaram, Y.N. Hosakote and Molakalmuru steadily increasing the usage of HEJ. Forecasting the demand, many mechanical jacquard manufacturers have started manufacturing different indigenous HEJ with salient features. The possibilities of frequent design change introduces numerous varieties of sarees in the market which readily attracts the lady customers and increase the marketability. Frequent design change in turn increases the demand for saree layout fashion designers, graph designers, day by day. Hence, fashion technologists should also focus to get trained in sketching beautiful attractive layouts for exclusive ceremonial silk sarees – the loom made garment by carrying systematic trend analysis.

The textile technologists should also focus to learn computer aided graph designing to convert the given layouts into graph designs with required weaves and colour combinations and transfer the same to HEJ.

XII. ACKNOWLEDGEMENT

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[7] Manufacturer, Harness Builder, Designer and Weaver of Onnupuram, Vazhapandhal and Durugam villages of Arni Silk Handloom cluster.